ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Report On

PROJECT NO. 1 - COLD WEATHER OPERATIONS
PROJECT NO. 2 - OPERATIONS AT HIGH TEMPERATURES

Subject: A Critique of Army Rations; Acceptability and Deitary Requirements

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Project Nos. 1-7, 1-17, 2-5, 2-14

10 April 1944

ARMORED MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 1-7,1-15 - 2-5,2-14 10 April 1944
File No. 430.2

A Critique of Army Rations; Acceptability and Dietary Requirements

1. PROJECT: Project No. 1 - Cold weather operations. First partial report on: Sub-project 7, Test of Adequacy of all combat zone rations intended for use in sub-zero climates: Sub-project 15, Study of the total and specific dietary requirements for cold weather. Project No. 2 - Operations at high temperatures: Sub-project No. 5, Test of Adequacy of all combat zone ration intended for use in Operations at high temperatures: and Sub-project No. 14, Study of total and specific Dietary Requirements for Operations at high temperatures.

a. Authority: Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, File No. 400.112/6 GNOHD, dated September 24, 1942.

b. Purposes:

(1) To review the energy (oxygen and calorie) requirements of soldiers in various activities.

(2) To estimate the ideal ration for satisfying energy and other nutritional requirements.

(3) To determine how well rations as issued and as consumed satisfy ideal specifications, (1) in training areas, and (2) in combat theaters.

2. DISCUSSION:

a. Various army rations have been developed under the acute necessity of urgency, and others have evolved slowly from peacetime practices. In view of (1) the increasingly narrow gap between food supply for the country and overall demand; and (2) reports of unsatisfactory feeding of troops in certain combat areas, it is important to examine current rations and dietetic regulations from theoretical and practical view points. These include appraisal of:

(a) The acceptability and satisfying qualities of the diet as well as the caloric and nutritional (vitamin, mineral, carbohydrate, protein, water and fat) content.

(b) Use of rations under conditions for which they were not intended; e.g. the use of K or C rations for many weeks in combat.

(c) *Regulations which affect the quantity of food available to each soldier, especially where conditions preclude regular attendance at mess.*

(d) The effect of unusual environmental conditions upon palatability, acceptability, stability and keeping qualities of rations, and upon dietary requirements.

(e) The validity of standards set up for daily needs of vitamins, minerals and other constituents of food.

(f) Waste, spoilage, deterioration, packaging.

3. CONCLUSIONS:

a. The emergency rations K and C are satisfactory as emergency rations (3-5 days). When they are used for long periods, they present the grave fault of monotony; certain components are thrown away so that the portions still eaten do not constitute a balanced diet and do not satisfy the soldier. Vitamin deficiencies have occurred in the field from protracted use of only those parts of the ration still acceptable.

b. The field and garrison rations are satisfactory. It is possible that some waste can still be reduced by attention to the eating habits of soldiers and avoiding foods which are not generally eaten.

c. Suggested requirements for an ideal emergency ration which will permit its general use in many circumstances, are listed in Appendix B, Table 1.

d. Ration requirements based upon tests carried out in camps, training areas, maneuvers and in the laboratory may give ideas about different rations which cannot be verified except by detailed study of rations in theaters of combat, and in the front lines.

4. RECOMMENDATIONS:

a. If an emergency ration is to be used for more than a week at a time, it should be modified in accordance with the specifications in Appendix B, Table 1.

b. Testing of rations in non-combatant zones should be validated by tests in combat theatres.

c. The determination of acceptability, adequacy and use of rations should be a Medical Corps as well as Quartermaster Corps function.

(NOTE: The conclusions and recommendations set forth above have been concurred in by Headquarters, Armored Center, W. H. Nutter, Colonel, G. S. C., Chief of Staff.)

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2 Incls.
#1 - Appendix A
#2 - Appendix B

APPENDIX A

I. EMERGENCY RATIONS.

Emergency rations were designed to tide the soldier over during phases of combat when usual messing practice is impossible. They were designed for use by paratroopers, by assault troops, in establishing beachheads, and in certain types of patrol activity. Use in air operations, in amphibious warfare and in life rafts was a logical development. A number of specialized rations, B, C, D, K, 10-in-1, 5-in-1, mountain, desert and jungle have been developed, tested and, in many instances, used in the field. Implicit in the specifications for such rations has been the belief that they should be nutritionally perfect, that they satisfy the daily requirement not only of calories, but of each vitamin and mineral. It has also been the aim to have a single ration for emergency use in desert, jungle, arctic and temperate zone theaters.

If the emergency ration was used for emergencies only, almost any one of those listed above would be satisfactory in practice; however, particularly where the supply problem has been difficult (as it usually is), emergency rations have been used for long periods. There are many reports of C or K rations singly or combined being used continually in combat for 1-2 months -- even as long as 67 days in one instance. Those in charge of supply have taken the easy way, or perhaps the only way out, and put emergency rations to the use for which field rations were intended. This has resulted not only in depressing morale, but also in the occurrence of actual vitamin deficiency diseases. Some observers have said that the combat efficiency of troops in some areas had been reduced by two-thirds.

The satiety effect of many components of emergency rations increases with time. As an example in the K ration, the K1 and K2 bisquits, the meats, the dextrose, malted milk tablets are rarely eaten. The soldier subsists on the gum, cigarettes, fruit bar, cheese, candy and beverages, although he discards the lemon juice in Italy and in warm regions where no ice is available. As a consequence, he loses much weight - reports of 20-40 lbs. lost in 2 months at the front are not rare. He may develop vitamin deficiencies. Thus the attempt to assure a high vitamin intake has defeated the whole purpose of the emergency ration.

This dilemma may be escaped by :

1. Using the emergency ration for short periods only (3-5 days). By the nature of warfare and the practice of supply, it is evident that field mess will not be possible in many situations so this alternative may be expected to fail in the future as it has in the past.

2. Alteration of emergency rations to permit more general acceptance by the soldiers.

In Table I suggested specifications for emergency rations have been listed. Attention is drawn to the order of importance of these requirements. First the ration must be accepted by most of the men most of the time. It is

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worse than useless to supply a theoretically perfect food which the soldiers will not eat. No matter what the dietetic value of an item, the prime requisite is that it be eaten and satisfy the soldier. Where the acceptability is established, the food values can be checked. A few instances of failures from past experience will illustrate some of the difficulties which may affect the morale and performance of soldiers.

In the experience of the First Armored Division in North Africa the C ration, on which the division subsisted for many months, was inadequate as to vitamin and salt content. A considerable number of symptoms of vitamin B deficiency were common. It was recommended that both salt and poly-vitamin tablets be included in each biscuit tin. An adequate amount of sugar was not furnished with the lemon powder which was the sole source of vitamin C; therefore, the troops did not use it. It was suggested that about 5 or 6 types of meat instead of 3 would render the C ration much more palatable. Troops usually preferred the C rations to the K ration. C rations actually made men sick. Cold meals over a prolonged period produced gastritis, associated with nausea, vomiting and occasionally diarrhea. A ration to be in fact a ration must be eaten. Neither C or K rations could be generally consumed by troops beyond a very few days (estimates, 2-6 days). To be eaten, the rations must be more attractive, appealing to the American taste. No ration with so much health built in was considered likely to appeal to, or be well consumed by American troops.

An observer from the Italian theatre noted -- "Losses of weight after 2 months on the K and/or C ration ranged from 20-40 pounds. Hot meals were rare in forward areas. The K ration did not fill the belly. In areas behind the front lines where a rest and changes were looked for, the men were often given the same emergency rations, which they were sick of. The cold drink in the K ration was thrown out during the winter, or was used as a substitute for baking powder which was scarce. The pattern of food dislikes appeared to be fixed by early experience with a ration under adverse conditions. Because of irregulatiry of messing, some provision is needed to see that the man who misses a meal in time of duty doesn't go hungry for 15-20 hours. A snack-bar open 24 hours would prevent this and allow extra food for men doing unusually heavy work".

A case of clinical pellagra with skin and tongue lesions was seen by another observer in a soldier too long on C and K rations.

Powdered milk was not used in Aleutian campaign because men had not been instructed in its use.

While such failures of food may be exceptional, they have occured in many theaters. In most cases, the difficulty could be corrected by never using an emergency ration for long periods. If it appears that such rations will continue to be used for more than a few days, the ration must be altered, variations added, simplifications made in accordance with the specifications in Table 1. The improved ration, after sufficient field testing in training areas in this country, should be combat tested and every effort made toward getting the final product to the men in combat in a form which he will eat. Since an Army travels on its stomach, the logistics of food supply is as

important as that of shells. And by the same token, labor spent in the transport of inedible food to the front line soldiers may be compared to bringing up duds for the artillery.

II. INTERMEDIATE ZONE RATIONS.

Between the garrison ration or field equivalent and the emergency ration is a terra incognita where the type of food varies greatly from theater to theater. An attempt is made to supplement food shipped overseas by local produce. Problems of logistics as well as the state of local agricultural and farming determine the practices which, however, must fall within the regulations set up by the local quartermaster under the theater commander. As may be expected there has been great variation in the results where so many unpredictable circumstances operate.

III. THE GARRISON RATION.

Under the garrison ration system, money is allotted to an organization for purchase of prescribed foods. The garrison ration is fixed by the President of the United States, and the actual amount spent varies with market prices, from station to station and from time to time. The organization commander is responsible for planning the meals; and individual tastes and ideas of an organization influence the resulting diet. Money not spend for food may be saved to be used later for food or special treats. A constant review by Medical Officers of practices under this system is necessary to keep the diet adequate for there is a tendency to feed well early in the month and stint towards the end. Where the field ration, or rationing-in-kind is practiced, menus are prepared under the direction of Service Command Generals and their advisers. A variable supplement to the food intake of soldiers in permanent camps comes from candy, soft drinks and beer from the post exchanges. This allows soldiers to obtain additional calories when meals are missed, or there is an increased expenditure of energy. No such reserve is available in many combat areas.

The garrison ration system has been found satisfactory in practice. Strict supervision has curtailed waste to a minimum and personnel familiar with operation of the system have been trained during the period of rapid expansion in the armed forces. Table 2 gives a detailed breakdown of the types of food for a sample month.

How this system works may be seen in Tables 3 and 4 which compare (1) the specific Army recommendations for various classes of activity, (2) National Research Council recommendations, (3) the planned diet for the month of December, 1943 at Fort Knox, Kentucky and (4) the actual food issued. A scrutiny of these tables shows a remarkably close agreement between these four categories. The absence of any nutritional deficiency disorder among soldiers of the camp during this period is further validation of the dietary practices.

Many pitfalls make the literal interpretation of dietary require-

ments given in the tables of great hazard.

1. *The tables are approximations of averages. There is marked discrepancy between similar items in various tables. Methods of testing vitamin and mineral content of foods are far from perfect.*

2. Foods from different regions may show a significant variation in dietary values depending on soil, fertilizer, rainfall, sunlight and variety of plant crops. These factors also affect the animals raised in different regions and later used for food.

3. Food as issued is not the same as that finally converted to fuel and reparative processes by the individual soldier.

a. Deterioration may occur in transportation.

b. Deterioration may occur in storage.

c. Deterioration may occur in preparation for cooking, Table 5.

d. Deterioration may occur in cooking, Table 5.

e. Deterioration may occur while food is kept hot before serving.

f. Waste may occur: all that is served is not eaten.

IV. THE VITAMIN REQUIREMENT OF SOLDIERS.

For any protracted period, all dietary needs should be satisfied; for shorter periods men can work vigorously and safely without continual replacement of various factors essential for long term activity. Depletion of dietary factors leads to deterioration in performance and danger to health at rates which bear a roughly inverse relationship to their customary availability. During work, oxygen-want produces symptoms within a matter of seconds, lack of water within a few hours, of energy foods within a day, of salt within a few days, while vitamins and certain minerals can be missing from the diet for weeks without disaster. The body has reserves effective against short term starvation.

It has been assumed, chiefly from animal experiments and anthropological observations, that if certain food factors are provided in quantities well above the minimal needed for existence, better health will occur. Such a subsistence level is said to be optimum. Scientific demonstration will need generations to establish this in man. There is even some evidence that man can adapt himself to live successfully on diets which contain some vitamins in only a small percentage of their supposed minimal concentrations (Meyers, Am. J. Med. Sc., 201: 785, 1941; Najjar & Holt, J. A. M. A., 123: 683, 1943). Nonetheless, in view of disorders which occur in dietary difficulties of many sorts, the National Research Council set up rather high tentative daily allowances of calories, minerals and vitamins (See Table 6). Current emphasis on vitamins has elevated standards of feeding the Army. This has been satisfactory in the garrison and field rations. Most recruits gain several pounds during the early months of training. Soldiers do not

eat all of some items of vitamin-rich food. This is notoriously true of liver which is largely wasted in the Army Mess.

An unexpectedly evil effect of emphasis on high dietary requirements is seen in emergency rations. The high vitamin content has necessitated use of rich, sometimes greasy and often unpalatable, components which are discarded so generally that the diet as eaten is unbalanced. This is of grave import when the emergency ration is used for long periods, as has happened in several theaters.

Recent work from the Laboratory of Physiological Hygiene of the University of Minnesota under the direction of Dr. Ancel Keys has demonstrated that deficits of B complex vitamins are well tolerated by men doing hard work for many days. This is at variance with previous ideas. With other consideration, it requires a basic reappraisal of the concepts upon which emergency rations have been designed.

V. THE ENERGY REQUIREMENT OF SOLDIERS.

a. The energy, fuel of caloric requirement of soldiers is governed by the following principles:

1. The fuel requirement rises as work becomes harder and more prolonged.

2. The fuel-food need varies with size; a small man needs less than a large one doing the same work. Although the Army mess is organized to feed the average soldier, anthropometric measurements demonstrate significant variations (ranges of from 72-137% of the average - Table 7).

3. It is not known whether the stress of combat, the hazards of battle, and the emotional turmoil and physical fatigue associated with them cause any alteration in the food requirements. It is certain that alimentary functions are upset, that digestion may be impaired, that appetite may vanish. Other less well understood factors may cause inequalities in food requirements of men of equal size and equal energy output.

4. There is no evidence that operations in desert or jungle increase energy requirement. It may be reduced. Cold weather operations, however, increase the caloric requirement appreciably; in arctic operations, it may increase more than 1000 calories per man per day (See Table 11).

5. Diarrhea and other conditions of disease in troops may alter requirements or interfere with nutrition in other ways.

b. Table 8 shows what a recruit weighing 150 lbs. may be expected to burn in accomplishing some tasks in training. From Tables 7-11 may be computed the expected energy requirements for any group of men of average size. These tables give only an approximate gauge of the calories or energy required for the types of activity a soldier experiences in training and some forms of combat.

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APPENDIX B

The data presented in the several tables and much of the information on which this report is based have been obtained from medical and scientific literature, from studies carried out by the Laboratory, and from information obtained from combat surgeons and medical observers who have seen conditions in the field. It is emphasized that some of the figures presented are tentative. They represent the nearest approach to exact measurements available with existing techniques, but must be used as rough gauges only.

SOURCES:

1. Armored Medical Research Laboratory Reports
2. Harvard Fatigue Laboratory Reports
3. University of Minnesota Laboratory of Physiological Hygiene Reports
4. Tables of Allowances recommended by National Research Council
5. Personal reports from observers, division surgeons and troops
6. Nutrition as it affects Military Personnel, Col. P. E. Howe, Med. Clinics of North America - 27: 581, 1943

TABLE 1

SPECIFICATIONS FOR EMERGENCY RATIONS
IN ORDER OF IMPORTANCE

I. Acceptability and Palatability*

No item in ration not used regularly by 80% of men after a month of constant use of ration.

The meal must satisfy hunger and fill the belly.

No single item, which if not used, would render ration totally unbalanced.

Acceptable hot or cold - if unacceptable cold, heating provisions must be available with the ration as issued.

Common American foods, not exotic types, be used.

Blandness in all foods. If seasoning is supplied, keep it separate so it may be used to taste.

Variation: At least 2 and preferably more alternate menus for each meal, or its main constituent, must be available for rotation when ration is used 3 or more days.

* Unless this requirement is met, the ration is of very little value.

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II. *Food Properties*

Ration must supply adequate calories as eaten.

If to be used longer than 10 days, vitamin and mineral requirements should be met. This should not be done at the expense of acceptability.

III. Stability

Packages for shipment and storage must witnstand exposure for several months to expected ranges in these conditions without alteration of essential characteristics:

Moist Heat	Fresh Water	Sand
Dry heat	Salt water	Mud
Radiant Heat		Dust
Cool		
Cold		

And various combination of the above.

IV. Packaging

Individual units should fit pockets snugly and comfortably; be water and sweat proof; be so packaged that flavors do not intermingle; hold up under ordinary combat, patrols, landing operations; be readily available, opened with minimum of equipment, when in dark; have efficient ratio of food value to volume and weight; be so labelled as to be identified at glance with stable label (see Par. III.), be camouflaged, and so packed that individual items cannot be stolen from large or small issue units. Opening containers must not endanger opener.

V. Physiological Characteristics

Must not tend to cause:

Undue thirst

Nausea

Vomiting

Diarrhea

Constipation

Gas

Allergic reaction

VI. Miscellaneous

No main item in emergency ration which is standard ration in relief areas.

Some provision for individual variation in need. Extra rations or supplements of particularly desired items should be included in the larger packages for distribution.

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NUTRITIONAL CONTRIBUTION (PER CENT) OF VARIOUS CLASSES OF FOODS

Based on food prescribed for U.S. Army

May - October, 1941

Group	Lbs/man/day	Unit Wt.	% Calories	% Protein	% Fat	% C(OH)	% Ca	% P	% Fe	% Vitamin A	% Before Cooking Thiamin	% Riboflavin	% Nicotinic Acid	% Ascorbic Acid
Meats, fish and Poultry	.7-.9	.8445	21.8*	42.1*	41.2*	.3	3.4	29.9*	33.8*	14.6*	52.8*	30.1*	65.3*	1.8
Eggs, fresh	.15-.17	.1777	2.6	7.1	4.2	.1	3.8	7.4	7.9	5.4	4.9	12.8*	.1	-
Milk Products (Equivalents)	1.00	1.0850	9.0	13.3*	11.7*	5.3	59.6*	22.8*	4.0	8.6	4.4	29.5*	1.5	3.1
Butter	.07	.0930	7.1	.2	17.5*	.0	.7	.3	.3	10.5*	.0	.1	.2	-
Fats, other	.05	.0847	7.6	.1	18.8*	.1	.0	.0	.0	.1	.0	.0	.1	-
Grain Products	.6-.7	.7373	23.3*	22.6*	5.3	38.8*	11.7*	17.5*	16.6*	.1	14.6*	7.7	10.5*	-
Legumes, dry	.03-.05	.0660	2.5	4.9	.5	3.6	3.5	6.4	11.0*	-	5.3	3.2	2.8	-
Sugars, syrups	.25	.3449	13.4*	.3	-	28.2*	1.3	.3	3.1	-	-	-	-	-
Vegetables, leafy, green or yellow	.3-.5	.4202	1.5	2.3	.2	2.5	6.0	3.1	6.0	46.7*	4.1	3.6	3.8	33.1*
Tomatoes	.1-.15	.1603	.5	.6	.1	.8	1.0	1.3	1.7	4.7	1.9	1.1	1.2	9.0
Citrus Fruits	.3	.2097	.7	.3	.1	1.3	1.9	.7	1.0	.1	1.6	.5	1.1	17.7*
Potatoes, white	.6-.7	.6540	5.0	4.0	-	9.3	1.9	6.0	7.5	.7	7.4	4.4	9.9	17.8*
Vegs., other	.2-.3	.3006	1.3	1.4	.2	2.2	3.0	2.6	2.3	.4	1.2	2.3	.9	10.5*
Fruits, fresh & canned	.25-.35	.4098	2.7	.6	.2	5.5	1.4	1.0	2.2	6.0	1.2	2.5	1.9	7.0
Fruits, dried	.03-.05	.0342	1.0	.3	.0	2.0	.8	.8	2.5	2.1	.5	2.0	.8	-
Weights & Units			4200	128gm	192gm	490gm	980mg	1980mg	24mg	13500 iu	3.3mg	2.6mg	29.5mg	129mg

* Contribute 10% or more of daily total

TABLE 2

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CLASSIFIED FOOD ALLOWANCE
U.S. Army (in lbs/man/day)

Class	Moderate Activity		Average for Army	Very Active Troops		As Planned Ft. Knox December 1943	As Issued
	A-1	A-2		B-1	B-2		
Meats, Fish and Poultry	.75	.75	.84	1.00	1.00	.975	.914
Eggs, fresh	.125	.125	.18	.125	.125	.169	.177
Milk Products	1.00	1.00	1.09	1.00	1.00	1.13	1.18
Butter	.10	.10	.09	.125	.125	.070	.070
Fats, other	.056	.056	.08	.075	.075	.051	.026
Grain Products	.50	.50	.73	.88	.90	.635	.483
Legumes, dry	.031	.03	.07	.10	.12	.045	.041
Sugars & Syrup	.25	.25	.34	.25	.33	.345	.337
Vegetables, L. G. & Y.	.44	.33	.42	.44	.33	.421	.448
Tomatoes	.31	.28	.37	.20	.25	.103	.104
Citrus Fruits						.269	.250
Potatoes, white	.50	.70	.65	.90	1.00	.574	.572
Vegetables, other	.50	.25	.30	.50	.25	.256	.235
Fruits, fresh & canned	.50	.20	.41	.30	.25	.432	.382
Fruits, dried	.05	.05	.03	.10	.10	.028	.020
Total (lbs. per man per day)						5.533	5.219

TABLE 3

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DISTRIBUTION OF NUTRIENTS IN RATIONS AS ISSUED

Nutrient	Moderate Activity A-1	Moderate Activity A-2	Moderate Activity Average	Very Active Troops B-1	Very Active Troops B-2	As Planned Ft Knox	As Issued Dec '43	National Research Council Recommendation
Calories	3,556.00	3,468.00	4,331.00	4,751.00	4,889.00	4,099	3,677	3000-4500
Protein gm	107.00	106.00	131.00	149.00	150.00	134	122	70
Fat gm	168.00	168.00	195.00	215.00	216.00	183	165	
Carbohydrate gm	403.00	382.00	513.00	552.00	585.00	481	424	
Calcium gm	0.91	0.86	1.01	1.03	0.99	1010	0.992	0.800
Phosphorus gm	1.71	1.68	2.03	2.29	2.29	2036	1899	
Iron mg	20.00	20.00	24.00	29.00	29.00	26.6	24.1	12.00
Vitamin A. I.U.	13,404.00	11,560.00	13,274.00	13,785.00	10,462.00	13,696	11,157	5000
*Thiamine mg	2.51	2.49	2.99	3.49	3.49	2.35	2.16	1.8 - 2.3
*Riboflavin mg	2.49	2.40	2.80	2.99	2.94	2.70	2.29	2.2 - 3.3
*Nicotinic Acid mg						31.4	28.4	15 - 23
*Ascorbic Acid mg	134.00(97)	105.00(74)	140.00(97)	135.00(110)	105.00(73)	100	96	75

*Corrected formoderate cooking losses. Values for ascorbic acid in parenthesis.

TABLE 4

TABLE 5

VITAMIN LOSSES IN COOKING AND SERVING

Thiamin

Meats 50%
Processed Meats 80%
Cooked vegetables 25% if cooking water is retained
Cooked vegetables 50% if cooking water is discarded

Riboflavin

Meats 30% Negligible losses if entire process done in dark.

Nicotinic acid

Negligible

Pantothenic acid

Moderate to slight in vegetables; up to 30% in meats.

Biotin

Moderate to negligible in vegetables; up to 75% in meats.

Inositol

Very great in vegetables (up to 95%) moderate in meats.

Folic acid

Very great for most foods.

Vitamin C

Cooked vegetables 50% - higher in metal containers
Dehydrated foods - near 100% - higher in metal containers - newer methods of dehydration have greatly reduced this loss.
Salads prepared beforehand-and left for sometime - 20-30% - higher in metal containers.

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TABLE 6

RECOMMENDED DAILY ALLOWANCES FOR SPECIFIC NUTRIENTS
COMMITTEE ON FOODS AND NUTRITION, NATIONAL RESEARCH COUNCIL

154 lb. man	Calories	Protein Grams	Calcium Grams	Iron mg	Vitamin A Units	Ascorbic Acid mg	Thiamin mg	Riboflavin mg	Nicotinic Acid mg
Sedentary	2,500	70	0.8	12	5,000	75	1.5	2.2	15
Moderately Active	3,000	70	0.8	12	5,000	75	1.8	2.7	18
Very Active	4,500	70	0.8	12	5,000	75	2.3	3.3	23

TABLE 7

WEIGHT OF 2960 SOLDIERS

Distribution in Percentiles
Weight in Pounds

Weight	Percentiles
128.5	5
133.8	10
137.2	15
139.8	20
142.1	25
144.5	30
146.5	35
148.7	40
150.8	45
153.1	50
155.3	55
157.4	60
159.9	65
162.4	70
165.5	75
168.8	80
172.7	85
177.4	90
184.0	95

Number: 2960
Range: 110-210
Median: 153.12

From: Armored Medical Research Laboratory report on Project No. 9, File No. 741-3 dated 1 February 1943; Anthropometric Measurements.

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TABLE 8

TABLE FOR ESTIMATING CALORIC EXPENDITURE

The energy requirements of soldiers may be determined by actual measurement of oxygen used in doing a specific piece of work, or by reference to tables in which the oxygen expenditure for standard types of work is recorded. In some instances where no data are available and direct measurement is not feasible, an estimate can be made. There is reasonably close agreement between calculated and measured oxygen requirements. The following tables give estimates or actual records of calorie expenditure for varying types of activity. From them, calculations for caloric requirements may be computed for practically any situation. It is not known whether the conditions of combat, extreme fatigue and other factors influence these estimates, but wide discrepancies are not anticipated.

For appraisal of the caloric adequacy of a ration, the following caloric output values for various military activities have been obtained. Many of these values have been checked on soldiers by the Douglas bag technique. The table gives figures for a soldier weighing 150 pounds. All values listed (except those marked with asterisk) include a ten minute rest period in each hour. The unadjusted caloric values per hour may be computed from the values below by subtracting 21, and multiplying the remainder by 6/5. Inspection of the table indicates that some of the activities listed must have been carried out under comparatively easy conditions. For instance, the caloric requirement for touch football and softball are both given as 188. The bayonet drill and gas mask drill look far too low compared with marching. The table should, therefore, be used to gain general rather than absolutely quantitative data.

Activity	Cals. per hour
Off duty	
Sleeping*	67
Eating*	75
Off Duty in Area	130
Clean Up	
Inspection	130
Policing Area	130
Toilet*	100
Fatigue details - raking up, etc.	130
Athletics	
Mass Games	271
Touch Football	188
Softball	188
Volley Ball	188
Wrestling, by pairs	310
Boxing, by pairs	310

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Basic Training Activities

Calisthenics*: 1/2 hour consists of 15 mins. standing about between exercises, and 15 mins. activity including 1 min. running in place, 50 side straddle hops, 48 squat hops, 15 pushups, 50 knee-bends, 10 mins. of light arm exercise.		300
Calisthenics with rifle		395
Close Order Drill		255
Close Order Drill with rifles		275
Bayonet Drill		201
Bayonet Drill dummies		201
Hand Grenade Drill		137
Manual of Arms		171
Gas Mask Drill		137
Rifle Marksmanship		171
Obstacle Course	338	(293)**
Obstacle Course with Rifles	396	(340)
Obstacle Course with Rifles and Pack	438	(393)

Marches (50 minute march plus 10 minute rest)

Retreat Parade	171
Field March	289
Field March with Rifles	338
Marching on level with light pack (27 lbs.) and rifle (9 lbs.), 50 mins. of marching and 10 mins. rest, covering 3 miles	410
Field March with Rifles and heavy pack; as above	455

Tank Driving

Driving M4A2 Tank over wooded terrain without* roads and with steep grades, deep gullies, sharp turns and deep mud.	320
Driving Bendix Power Control Tank over same terrain	212

NOTE: Under ordinary circumstances the driver may be considered as having the highest caloric requirements of members of a tank crew.

Extended Order and Maneuvers (Activity as described)

Field rushes with full equipment (repetition of 5 secs. running, 10 secs. lying prone). One hour consists of 10 mins. march to area; 40 mins. rushing in which 5 secs. running followed by 10 secs. lying prone is repeated for 40 min; 10 mins. rest at end.	415

** Respective values where activity consists of 20 min. obstacle course and 30 min. march to or from the course.

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Creeping and crawling with full equipment. One hour consists of 20 mins. marching, 10 mins. resting, 7-1/2 mins. creeping, 7-1/2 mins. crawling both high and low, with 15 mins. of prone resting	405
Creeping and crawling as above without equipment.	305
Obstacle course with light pack and rifle. Course lasts about 5 minutes and consists of pit jump, hurdles, log crossing, ditch jumps, maze run, log step climb, ditch climb up and down, 12 foot landing net climb, high tunnel run, log ladder up and down, broken field run, low tunnel crawl, rope swing, high fence climb, one log sitting bridge, walking log bridge, and parapet ditch jump. One hour consists of 20 mins. marching, 2 circuits of course and 20 mins. rest. (There is great variation in different courses.)	380
Digging fox holes. Two hours consists of 20 mins. march, eighty minutes of digging (half the time spent resting) followed by 20 min. break	240
Rifle Exercises. 1/2 hour consists of 15 minutes of standing about, and 15 mins. of exercises including 32 squat hops with rifle above head, 36 side lungs with rifle and other exercises as in Calisthenics, but with rifle.	450

TABLE 9

CALORIC EXPENDITURE OF A 150 LB.
SOLDIER DURING VARIOUS TYPES OF ACTIVITY

ACTIVITY	ENERGY EXPENDITURE (Cals/hr) CALCULATED BY GROUP AT CAMP LEE	ENERGY EXPENDITURE (Cals/hr) MEASURED BY HARVARD FATIGUE LABORATORY
1. Marching on level with light pack (27 lb. and rifle (9 lbs.), 50 mins. of marching and 10 mins. rest, covering 3 miles.	392	410
2. Field rushes with full equipment (repetition of 5 secs. running, 10 secs. lying prone). One hour consists of 10 mins. march to area, 40 mins. rushing in which 5 secs. running followed by 10 secs. lying prone is repeated for 40 mins; 10 mins. rest at end.	318	415

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3.	Creeping and crawling with full equipment. One hour consists of 20 mins. marching, 10 mins. resting, 7-1/2 mins. creeping, 7-1/2 mins. crawling both high and low, with 15 mins. of prone resting.	318	405
4.	Obstacle course with light pack and rifle. Course lasts about 5 minutes and consists of pit jump, hurdles, log crossing, ditch jump, maze run, log step climb, ditch climb up and down, 12 foot landing net climb, high tunnel run, log ladder up and down, broken field run, low tunnel crawl, rope swing, high fence climb, one log sitting bridge, walking log bridge, and parapet ditch jump. One hour consists of 20 mins. marching, 2 circuits of course and 20 mins. rest.	374	380
5.	Digging fox holes. Two hours consists of 20 mins. march, eighty minutes of digging (half the time spent resting) followed by 20 min. break.	240	-
6.	Calisthenics: 1/2 hour consists of 15 mins. standing about and 15 mins. activity including 1 min. running in place, 50 side straddle hops, 48 squat hops, 15 pushups, 50 knee-bends, 10 mins. of light arm exercise.	300	300
7.	Rifle exercises. 1/2 hour consists of 15 mins. of standing about, and 15 mins. of exercises including 32 squat hops with rifle above head, 36 side lunges with rifle and other exercises as in 6, but with rifle.	418	450

TABLE 10

CALORIC EXPENDITURE DURING TWO SAMPLE DAYS (150 lb. SOLDIER)

			VALUE USED BY GROUP AT CAMP LEE (Cals.)	VALUE, MEASURED OR CUSTOMARILY USED, BY HARVARD FATIGUE LABORATORY (Cals.)
		1st Sample Day		
0500	AM	1st Call		
0510		Reveille	22	25
0515-0545		Calisthenics	250	150
0545-0600		Rest & Fatigue duties	33	25
0600-0630		Breakfast	54	55

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0630-0730		Calisthenics with rifle	418	450	
0730-0830		Creeping & crawling	318	305	
0830-0930		Field March	319	310	
0930-1030		Obstacle Course	374	380	
1030-1130		Field March	319	310	Hot
1130-1200	PM	Rest and fatigue duties	65	50	Weather
1200-1245		Dinner	56	85	Schedule
1245-1445		Rest and fatigue duties	130	200	
1545-1645		Boxing and Wrestling	375	350	
1715-1730		Rest and fatigue duties	33	25	
1730-1815		Supper	56	85	
1815-1915		Close order drill	200	280	
1915-2015		Calisthenics with rifle	417	450	
2015-2130		Fatigue duties	163	190	
2130-0500	AM	Bed	502	525	
		TOTALS	4104	4250	

2nd Sample Day

0500	AM	1st Call			
0510		Reveille	22	25	
0515-0545		Calisthenics	250	150	
0545-0600		Rest and fatigue duties	33	25	
0600-0620		Breakfast	25	35	
0620-0645		Fatigue duties	54	50	Normal
0645-1145		Road march	1960	2050	Weather
1145-1200	PM	Fatigue duties	33	30	Schedule
1200-1220		Dinner	25	35	
1220-1315		Rest and fatigue duties	119	110	
1315-1615		Road march	1176	1230	
1615-1730		Fatigue duties	166	150	
1730-1750		Supper	25	35	
1750-2130		Off duty in area	478	365	
2130-0500	AM	Bed	502	525	
		TOTALS	4868	4815	

TABLE 11

Summary of daily caloric requirement for complete balance in a 150 lb. man performing various types of duty.

		Calories
Sedentary	Clerical	2,500
Moderate Work	Driving vehicles	3,300
Hard Work	Jungle patrols, armored maintenance	4,000
Very Hard Work	Mountain patrols, construction, landing operations	4,800
Extreme Work	Forced marches, opposed landing operations, high speed construction.	5,500

Note: Add at least 1,000 calories for arctic operations.

Incl #2